Chapter 10
Polyphenols in Medicinal Plants

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Abstract

The long historical use of medicinal plants is fully acknowledged and the literature concerning the potential benefits from a health perspective is growing due to the recent rise in awareness of natural approaches for treating ailments. Plants (whole or any particular part of a plant) which can be used for medicinal purposes are included in the category of medicinal plants. These plants have been used in the traditional system of medicines for thousands of years, be it Ayurveda, Unani or Siddha. As a rich source of polyphenols and many other bioactive agents that have beneficial effects on human health, prevention and cure of many diseases. This chapter focuses on the polyphenolic constituents of various medicinal plants and their health promoting effects viz., antibacterial, antioxidant, anti carcinogenic, mental health and memory enhancement, anti-infective, cardioprotective and many others. Varuna or *Crataeva nurvala* is rich in phytochemicals and has excellent anti infective and wound healing properties. Arjuna/*Terminalia arjuna* is used in indigenous medicine systems like ayurveda, siddha and unani realising its potential biological medicinal abilities especially for cardiac ailments. Shatavari is an Indian herb having rich antioxidant properties due to its good polyphenolic content. Arandi popularly known as ‘castor plant’ have antimicrobial, anti-fungal, antioxidant properties. *Swertia chirata* (Chirayta), is a medicinal plant known to be a source of an excess of bioactive

phytoconstituents of immense health benefits. The roots, rhizome and seeds of Jatamansi have antimicrobial, antidiuretic, antidepressant, anti-cancer, antibacterial, antioxidant properties. Medicinal plants like brahmamanduki, kutki, brahmi and gurmar contain good quantities of polyphenols and are beneficial for human health. As a natural source of polyphenols, these medicinal plants have multiple health benefits.

Keywords: Medicinal plants, polyphenols, pharmacological activities, phytochemistry, polyphenolic constituents

Introduction

Any plant can be considered as a medicinal plant, which contains certain substances in one or more of its parts, that can be used for therapeutic purposes and/ or which are precursors for the synthesis of useful and beneficial drugs (Sofowora *et al*., 2013). Since time immemorial, medicinal plants are in use to treat various kinds of ailments in traditional medicine systems like Ayurveda, Unani and Siddha. During the last few decades, there has been a rise in curiosity and interest in treating health problems with natural and herbal products due to less risks of side- effects. The raised awareness has led to a significant amount of research and experimentation on medicinal plants.

Among various bioactive molecules, polyphenols are recognised for their wide distribution in botanicals. It has already been established by several studies that the various compounds of polyphenols are linked for their potential abilities in maintenance and treatment of human health and that is why these plant based compounds have become an emerging field of interest in medical and nutrition sciences recently. Abundantly found in many plants, polyphenols are naturally occurring extraordinary sources of diverse quality containing compounds for multiple health benefits. A large number of botanicals have been recognised as medicinal plants due to their outstanding polyphenolic content. Notable work has already been done on biological activity and promising application of a variety of polyphenols found in some medicinal plants has already been executed. The chapter will provide a current understanding of polyphenolic content and related biological effects of few medicinal plants and their relevance to human health.

Varuna

General information, morphology and habitat

Crataeva nurvala is a medicinal plant of high therapeutic value and has been used in traditional medicine extensively. In the honour of the Greek botanist "Crataevas", the plant was named with the genes *Crataeva* and is scattered all over the world in about 70 species (Tabassum *et al*., 2018). *C. nurvala* attains its name as Varuna (the God of water, as per Hindu religion) in Sanskrit due to its potent effect on bodily fluids and renal system.

Crataeva nurvala is a medium sized tree, deciduous and generally reaching up to a height of 30 metre. The leaves are trifoliate (about 3.6 - 8 centimetres) with leaflets of oval shape. The developed bark bears a thickness of 5- 15 millimetres (Khatun *et al*., 2015). Every year it bears flowers in March and fruits in the month of June (Kumar *et al*., 2020).

The tree is found throughout India, especially in semi- arid regions of the country. It is also distributed in Bangladesh, Sri Lanka, Myanmar, Malaysia, Indonesia and China. In India, it is mostly found along Himalayan range. Various places like Karnataka, Kerala, Tamil Nadu, Sikkim and Andaman & Nicobar Islands also show the presence of *C. Nurvala* (Kumar *et al*., 2020).

Vernacular identification

Crataeva nurvala is commonly known as Varuna [Sanskrit], Varun [Hindi], Vayavarna [Gujarati], Varanam [Tamil], Ramala [Marathi], Narvala [Kannada], Barna [Punjabi], Borun [Bengali].

Taxonomic classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Brassicales

Family: Capparidaceae

Genus: *Crataeva*

Species: *Nurvala*

Image 1: *Crataeva nurvala* plant

Phytochemistry and polyphenolic constituents

Studies conducted on different species of the plant reveals its rich content of saponins, flavonoids, phenolics, tannins, phytoesterols, alkaloids, triterpenoids, anthracene derivatives and various volatile oils. Various parts of the plant show different polyphenolic content.

The **root bark** contains quercetin, lupeol, β- epilupeol, varunol, β-sitosterol acetate, β-sitosterol, ɤ taraxasterol and rutin. It also contains stearic, oleic, lauric, lenoleic acids and cysteic acid (Kumar *et al*., 2020).

Stem bark also exhibits a significant presence of polyphenols. Chief constituents are friedelin, β-sitosterol, catechin, glucocapparin, betulinic acid, cetyl alchol, lupeol, 5-O-β-D-glucoside and some alkaloids as cadabicine mether and cadabicine diacetate. Total phenolic content of about 195.2 mg gallic acid equivalent (GAE) per gram [195.2 GAE mg/g] and 218.34 mg per gram of catechin equivalent (CE) [218.34 mg/g CE] has been reported in dried stem bark powder (Kumari & Kakkar, 2008).

Leaf of the plant contains methyl pentacosanoate, rutin, dodecanoic anhydride, methyl pentacosanoate, kaempferol- O-α-D-glucoside, Lstachydrine, quercitin-3-O-α-D-glucoside, isoquercetin and quercetin. Dried leaf powder shows total phenolic content of 45.53 mg GAE/ gm (Khatun *et al*., 2015).

Fruits contain β-sitosterol, friedelin triacontanol, gluco-capparin, triacontane, 12 tricosanone, pentadecane, cetyl alcohol and octanamide. **Flowers** has methyl pentanoate, 9-heptadecanone, heneicosane, 1-eicosanol and 1-octadecanol (Gangandeep & Kalidhar, 2009).

Pharmacological activities associated with polyphenolic contents of plant parts

Root bark- Useful in eye infections, cardio protective, wound healing, laxative.

Stem bark- Anti urolithic, anti-diabetic, cytoprotective, anti-oxidant, anti-inflammatory, anti-arthritic, anti-periodic, anti-poisonous, hepaoprotective, anti-urolithiatic, useful in urinary tract infections, anti-obesity, lung protective.

Leaves- Diuretic, nephroprotective, stomachic, anti- rheumatic, useful in spleen enlargement, anti-pyretic, anthelminthic, demulcent, anti-hyperglycemic, anti-edemic, antihepatotoxic, anti-tumor, chemoprotective, cytotoxic, hypotensive, anti-diarrheal, contraceptive.

Fruits- Purgative, relieves constipation.

Flowers- Anti bleeding, anti- menorrhagia, anti- diarrhoea, useful in gastrointestinal disorders such as inflammatory bowel syndrome (IBS).

Whole plant- Anti protozoal, anti-fertility, anti-cancer, appetite enhance, cholegogue, immunity booster, blood purifier, memory enhancer, anti-histaminic, anti-cancer, anti-cataract, anti-ulcer, anti-aging, anti-allergic.

Arjuna

General information, morphology and habitat

Terminalia arjuna, also known as "Arjun Tree ", is a significant and widely used medicinal plant since ancient times. Various indigenous systems like ayurveda, siddha and unani utilised this plant by realising its potential biological medicinal abilities. According to 'Artharv Veda', traditional medical practitioners used this plant for treating 'Hritshool' (angina) i.e. severe chest pain mainly caused by insufficient blood supply and other cardiac ailments (Thakur *et al*, 2021).

Terminalia arjuna is a large, evergreen and deciduous tree. It can be up to 100 feet in length with a buttressed trunk and branches spreading horizontally. Bark is smooth and grey in colour. Leaves are conical and oblong in shape which are 10-15 cm long and 4-7 cm broad (Amalraj and Gopi, 2016).

About 24 species of *T. Arjuna* have been reported from different parts of India. The plant mainly shows its presence near the river side, ponds and rivulets. The distribution can be seen throughout sub- Himalayan regions of Uttar- Pradesh, Delhi, Punjab, South Bihar, Deccan, West Bengal, Madhya Pradesh and Orissa. It is also widely grown in Sri-Lanka, Burma and Mauritius (Thakur *et al*, 2021).

Vernacular identification

Terminalia arjuna, has many vernacular names as Arjuna [Common name], Aujun [Hindi], Arjhan [Bengali], Marudhu [Tamil and Malyalam], Sadaru [Marathi], Neer matti [kannada], Tella Maddi [Telugu], Sadado [Gujarati].

Taxonomic classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Myrtales

Family: Combretaceae

Genus: *Terminalia*

Species: *Arjuna*

Image 2: *Terminalia arjuna* plant

Phytochemistry and polyphenolic constituents

The plant shows a significant content of saponins, flavonoids, Glycosides, Tannins, Lactones, minerals and other trace elements.

Root contains Triterpenoids and Glycosides as Arjunolic acid, Arjunoside I-IV, Oleanolic acid, Terminic acid and Arjunic acid (Amalraj and Gopi, 2016).

Stem bark show the presence of Triterpenoids as arjunin, arjunic acid, arjunolic acid, arjungenin, terminic acid, ajunglucosides IV-V, ursane triterpenoids, other contents as glycosides like arjunetin, arjunolone, arjunolitin, terminoside A, aermionic acid, flavonoids and phenolics such as arjunone, luteolin, ethyl gallate, gallic acid, kempferol, oligomeric proanthocyanidins, pelargonidin, quercetin. A variety of tannins namely, pyrocatechols, casuarinin, punicalagin, terchebulin, terflavin C and minerals and trace elements as calcium, magnesium, aluminum, zinc, copper, silica have been reported in the plant. Compositional analysis of dried bark powder shows the presence of about 1% triterpenes, 5% ash, 12 % minerals, 30 % proteins and 44 % Polyphenols (Saha *et al*,. 2012).

Fruits has good content of arjunic acid, cerasidin, gallic acid, arjunone, fridelin, arachidic stearate, methyl oleaolate, b-sitosterol, hentriacontane and other triterpenoids and flavonoids (Dwivedi and Chopra, 2014).

Leaves and **seeds** contain alkaloids, steroids, oxalic acid, flavonoids, tannins, phenolic compounds, inorganic acid and cardenolide (Padmaa, 2010).

Pharmacological activities associated with polyphenolic contents of plant parts

Root- Useful in snake bites, scorpion sting, heptatoprotective, diuretic.

Stem Bark- Cardio tonic, anti- dysentery, styptic, urinary astringent, anti-ulcer, antacid, repellent and antifeedant activities, anti-diabetic, anti- ischemic, male sperm count enhancing, antiplatelet, inotropic, antihypertrophic and anti leukorrhea.

Leaves- Kill teeth worms, cure earache, anti-inflammatory, anti-oedema, anti-cancer, anti-fungus, blood purifier, useful in urinary disorders and skin disorders.

Fruit- Tonic, deobstruent, cure headaches.

Seeds- Anti- mutagenic.

Whole plant- Overall strength enhancing tonic, hypolipidemic, antibacterial, antiviral, antifungal, hypocholesterolemic, antioxidant.

Shatavari

General information, morphology and habitat

Asparagus racemosus is a broadly occurring perennial plant belonging to the family of *Liliaceae*. It is also known by the name of *Shatavari*, an Indian herb. The genus Asparagus comprises more than 250 species distributed throughout the world out of which 22 species of Asparagus are recorded in India (Singh *et al*., 2018).

The plant grows throughout the tropical and subtropical parts of India. The plant is a spinous under-shrub, with tuberous, short rootstock bearing numerous succulent tuberous roots (30–100 cm long and 1–2 cm thick) that are silvery white or ash colored externally and white internally. The fresh roots are fleshy and white in color while on drying it become shrinked and the color turns light brown.

The plant is mainly grown in tropical and subtropical regions of India and Himalayas up to an altitude of 1500 meters but also cultivated in Australia, Sri Lanka, tropical Africa and Indonesia (Sharma and Sharma, 2013).

Vernacular identification

Shatamuli [Bengali], Satawari [Gujrati], Satmuli [Hindi], Narbodh or atmooli [Madhya Pradesh], Aheruballi [Kannada], Chatavali [Malayalam],

Norkanto or satawar [Rajasthan], Shatavari or shatmuli [Marathi], Shatavari [Sanskrit], Sanspayiin [Himachal Pradesh] (Hasan *et al*., 2016).

Taxonomic classification

Kingdom: Plantae

Division: Angiosperms

Class: Monocots

Order: Asparagales

Family:Asparagaceae; Liliaceae

Genus: *Asparagus*

Species: *Racemosus*

Image 3: *Asparagus racemosus* plant

Phytochemistry and polyphenolic constituents

Asparagus racemosus rich in sapogenins and saponins. Different components of polyphenols and flavonoids with the active principles of shatavarin, sarasapogenin, racemosol and asparagamine are found in the roots of these plants.

Shoots of asparagus contain aldehyde, ketones vanillin, asparaguic acid; thiazole and its methyl and ethyl ester are used in giving flavors.

Their **flower** and mature **fruits** on a dry basis contain 2.5% rutin and quercetin. Diosgenin and quercetin 3-glucuronide are present in leaves. Approximately 3% protein, 5.4% saponins, 52.8% carbohydrates, 18% crude fiber, 4.1% inorganic matter and 5% oil are present in powdered roots.

Shatavari **root** powder has good antioxidant properties having a polyphenolic content of 5.78 mg per 100 gram. *Asparagus racemosus* is a phytoestrogens rich plant species. The majority of phytoestrogens belong to a large group of substituted phenolic compounds known as flavonoids. Other primary chemical constituents of *Asparagus* are essential oils, asparagine, arginine, tyrosine, flavonoids (kaempferol, quercetin, and rutin), resin, and tanninsteroidal glycosides (asparagosides), bitter glycosides, asparagines and flavonoids. A new isoflavone, 8-methoxy-5, 6, 4'-trihydroxyisoflavone 7-O-

beta-D-glucopyranoside from the roots of Asparagus racemosus is also reported. The antioxidant properties were found due to presence of Isoflavons specially racemofuran, asparagamine A and racemosol (Bharati and Kumar, 2019).

Pharmacological activities associated with polyphenolic contents of plant parts

Roots- Galactagogue, Estrogenic, Antioxytoxin Immunomodulators, Antidyspepsia, Antiallergic, Anticancer, Anti-inflammatory, Antidiabetic, Antioxidant, Antitussive, Hepatoprotective, Antibacterial, Antiulcer, Anti-diarrhoeal, Antilithiatic.

Leaves- Cholinesterase, Antiparasitic.

Shoots- Antiinflamatory, Antidiabetic and Diuretic.

Whole Plant- Antimicrobial and Cytotoxic, Nephroprotective, Hepatoprotective.

Aerial Parts- Urolithiasis, Hypolipedimic, Antiasthmatic and Antifertility

Seeds- Antiparasitic

Flower- Diuretic (Sachan *et al.*, 2012)

Arandi

General information, morphology and habitat

Ricinus communis, popularly known as ‘castor plant’, is one of the major oilseed crops of India. Castor is considered to be valuable and in demand as a major part of the oil produced is exported. India is the second largest producer of castor oil in the whole world. In Latin, Ricinus signifies tick and the plant is named after it as the seed of the plant has a bump at the end and a marking which actually resembles a certain tick. The plant is also commonly known as ‘Palm of Christ’ because of castor oil’s potent and powerful abilities to heal and cure wounds and other ailments (Khanum *et al*., 2018).

Ricinus communis is a fast growing, perennial shrub and soft wooden small tree with up to a height of 2- 6 metres. Leaves are 4- 20 cm long, broad, contain veins and have 5- 12 lobes. Plant has bright coloured flowers with feathery stigmas. Seeds vary in sizes and colour. Generally, it has a thick fleshy appearance, warty crust, oblong and smooth around 1- 1.5 cm in length (Jena and Gupta, 2012).

The plant is considered to be a native of the tropical part of Africa. Presently, it is widespread throughout the world with tropical and warm temperate regions. In India, it is very common and quite wild in jungles throughout river beds, banks of the stream and bottom lands or any hot and humid area. The presence is heavily reported in Bengal, Chennai and Mumbai (Rana *et al*., 2012).

Vernacular identification

Ricinus communis, is commonly known as Arandi, Endi [Hindi], Eranda[Sanskrit], Aranda [Bangali], Arand [Punjab], Erand [Maranthi], Diveli [Gujarati], Harlu [Kannad], Amanakku [Tamil].

Taxonomic classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order:Euphorbiales/ Malphighiales

Family: Euphorbiaceae

Genus: *Ricinus*

Species: *Communis*

Image 4: *Ricinus communis* plant

Phytochemistry and polyphenolic constituents

Photochemical studies of the plant reveal the presence of saponins, alkaloids, flavonoids, steroids and glycosides.

Root exhibits the presence of Quercetin 3-O-rhamnosylglucoside (rutin) and ricinitin majorly and also has other compounds as Indole-3-acetic acid, ricinusteryl benzoate, quercetin 3-0-glucoside and ricipiperanyl ester (Preeti and Verma, 2014).

Dried **leaf** powder contains ricinine, N-demethylricinine, saponins flavones, glycosides, alkaloids, quercetin 3-glucoside (isoquercetin), kaempferol, stigmasterol, β-sitosterol, lupeol, astragalin, reynoutrin, gallic and neochlorogenic acids (Abdul *et al*., 2018).

Seeds have 40- 45 % oil which contains ricinoleic acid in considerable amounts. It also has isoricinoleic, ϒ-sitosterol, fucosterol, stigmasterol and

many amino acids as glycine, tryptophan, proline, phenyl alanine, valine (Jena and Gupta, 2012).

Pharmacological activities associated with polyphenolic contents of plant parts

Root- Anti- diabetic, anti-Inflammatory, free radical scavenging, central analgesic activity, bone regeneration activity, purgative, hepatoprotective.

Leaves- Antimicrobial, anti-fungal, antioxidant, wound healing, lactagogue, anti-arthritic, antidandruff, anti-nociceptive.

Seeds- Cytotoxic, immune-modulatory, analgesic.

Oil- Insecticidal activity, antitumor, anti-implantation, anti-conceptive, estrogenic, antihistaminic, lipolytic, anticonvulsant, anti-helminthic, laxative and uterine contracting.

Chirayta

General information, morphology and habitat

Swertia chirata, is a medicinal plant known to be a source of a plethora of bioactive phytoconstituents of immense health benefits. The versatile use in the traditional system of medicine led to over- exploitation of the plant from its habitat, making it critically endangered and on the verge of extinction from the world. In India, around 40 species of the plant have been reported in the temperate Himalayan region (Aleem and Kabir, 2018).

The plant is biennial, which means continuing or lasting for two years. It shows vegetative growth for the first year and bears flowers and fruits for the second year. *Swertia chirata*, is a 0.5- 1.5 metre tall erect stem which is cylindrical and about 2-3 feet in length. Leaves are around 4 cm long, oval, broad at base, 5-7 veined and have a smooth surface. Flowers are tetramerous (containing four leaves) small in size with green- yellow, tinged with purple and white hairs. Roots are short, simple and yellowish, about 7-8 cm long and half inch in thickness (Kumar and Staden, 2016).

The plant can be found in high- altitude areas and is native of Himalayan area. Kashmir and Bhutan, which falls under sub temperate Himalayan regions of approximately 1200- 3000 metre altitude, have been reported with its presence of *Swertia chirata*. Moist and shady slopes of Khasi hills of Meghalaya also have their occurrence (Aleem and Kabir, 2018).

Vernacular identification

Charayatah [Hindi], Chiratika [Sanskrit], Charaita [Punjabi], Chireta [Bengali], Chirayita [Marathi], Nilavembu [Tamil], Nilavebu [Kannada]

Taxonomic classification

Kingdom: Plantae

Division: Tracheophyta

Class: Magnoliopsida

Order: Gentianales

Family: Gentianaceae

Genus: *Swertia*

Spicies: *Chirata*

Image 5: *Swertia chirata* plant

Phytochemistry and polyphenolic constituents

Studies conducted on whole plant phytochemical analysis and demonstrated that the species are rich source of Xanthonoids as bellidifolin, methylswertianin and mangiferin which are proven potent anti- diabetic agents (Kshirsagar, 2019). Other dervatives as flavonoids, lignans, alkaloids and some other compounds as palmitic acid, oleic acid, chiratin, stearic acid and ophelic acid are also present in significant amount (Naveen *et al*., 2017). Currently, 40 terpenoids and more than 50 Xanthonoids and have been isolated from the plant (Sharma *et al*., 2013). *Swertia chirata,* is also found to be rich source of iridoids/iridoid glycosides as amaroswerin, swertiamarin, gentiopicroside, mangiferin, sweroside, gentiopicrin, swerchirin and amaroswerin (Kshirsagar, 2019). Strong bitter taste is due to the presence of secoiridoid glycosides responsible for diverse medicinal and biological activities. Total phenolic content is reported as 0.234 % GAE (Gallic acid equivalent) (Naqvi *et al*., 2013).

Pharmacological activities associated with polyphenolic contents of plant parts

Stem- Antibacterial, analgesic, hepatoprotective.

Leaves - Antimalarial, hypoglycaemic, analgesic, antiviral, mutagenicity activity, gastro protective, wound healing activity, anti-dyslipidaemia,

antioxidant, ant carcinogenic, chemopreventive, useful cough, cold, fever, hyper pigmentation and osteoporosis.

Roots – Anti-inflammatory, antipyretic, analgesic, skin problems such as eczema and pimples.

Whole plant – Anti carcinogenic, antidiabetic, larvicidal, antihelmintic, antileishmania, antifungal, antibacterial, antidiarrhoeal, anti hiv, CNS depressant, anti-leprosy, anti-cholinergic, antitumor, antiulcerogenic, spasmogenic agent, antipsychotic, anti- hepatitis b virus, pro- hematopoietic, anti atherosclerotic, antiparkinson, anti-arthritic, anti- scabies, laxative.

Jatamansi

General information, morphology and habitat

Nardostachys jatamansi is a small, dwarf, hairy, perennial, rhizomatous, herbaceous, rare and most ancient species within the family Valerianacae. Distributed in the Himalayas from Pakistan, in India including Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim to Nepal, Tibet and China. It shows historical medicinal uses in Ayurveda, Homeopathy and the current medicine industry as well (Nakoti *et al*., 2017).

Nardostachys jatamansi DC is a small perennial rhizomatous herb which grows in steep, moist, rocky, undisturbed grassy slopes. The long sessile and oblong-ovate leaves are 15 to 20 cm in length. Flowers are slightly blue or pink in dense cymes. The root of this taxon consists of short, thick, dark grey rhizomes crowned with reddish brown tufted fibrous remains of the petioles of the radical leaves. Its rhizomes are used in traditional medicines in different medicinal systems (Sahu *et al*., 2016). The herbs and rhizomes of this hairy, perennial, dwarf and herbaceous plant are used for medicinal purposes.

It is a perennial herb growing to about 10–60 m in height and is commonly referred to as Indian spikenard. These plants are found in the Alpine Himalayas at altitudes of 3000-5000 meters, extending Eastwards and Kumaon to Sikkim and Bhutan (Razack *et al.*, 2015).

Vernacular identification

Jatamansi, Bhytajata, Tapaswani [Sanskrit], Musk-root, Indian spikenard, Indian nard [English], Balchara, Jatamansi [Hindi], Nard Indian [French], Bhutijata [Kashmir], Billilotan [Pu njab], Jatamavshi [Marathi], Jatamanji [Tamil], Jatamamsi [Assamese], Jatamamsi [Bengali] (Purnima *et al*., 2015).

Taxonomic classification

Kingdom: Planate

Division: Mangnoliophyta

Order: Dipsacales

Class: Mangnoliopsida

Family: Valerianaceae

Genus: *Nardostachys*

Species: *Jatamansi*

Image 6: *Nardostachys jatamansi* plant

Phytochemistry and polyphenolic constituents

The main active constituents in *Nardostachys jatamansi* are sesquiterpenes and coumarins. Valeranone or Jatamansone is the principal sesquiterpene (Nakoti *et al*., 2017). The major chemical constituents from roots and rhizomes of V. jatamansi are valepotriates, flavonoids and flavone glycosides, lignans, sesquiterpenoids, bakkenoloids type sesquiterpenoids, phenolics, essential oils and other phytochemicals (Jugran *et al*., 2018). Pandey *et al.*, 2013 estimated the total phenolic content in methanolic extract of *N. jatamansi* which was found to be 39.544 ± 2.16 mg/g. The phenolic compounds identified by HPLC were Protocatechuic acid; 596.5 ± 1.61 and Syringic acid; 68.5 ± 0.22. The 70% ethanolic extract of Nardostachys jatamansi (NJE) showed the presence of polyphenols and flavonoids (gallic acid, catechin, chlorogenic acid, homovanillin, epicatechin, rutin hydrate and quercetin-3-rhamnoside) analyzed by RP-HPLC, whereas hexane extract revealed an array of metabolites (fatty acids, sesquiterpenes, alkane hydrocarbons and esters). The identified polyphenols include gallic acid (0.18 mg/g), catechin (4.37 mg/g), chlorogenic acid (19.90 mg/g), homovanillic acid (32.02 mg/g), epicatechin (4.23 mg/g), rutin hydrate (0.08 mg/g) and quercetin-3-rhamnoside (7.13 mg/g) (Razack *et al*., 2015).

Pharmacological activities associated with polyphenolic contents of plant parts

Roots- Antimicrobial, Antidiuretic, Insecticidal, Antidepressant, Anti-cancer, Anticataleptic, Antibacterial, Antioxidant.

Rhizome- Anti ulcer, Antihypertensive, Anti diabetic, Anti-inflammatory, Heamatopoetic activity, Radioprotective (Rhizome powder), Anti-hypertensive, Antioxidative, Cardioprotective.

Seeds- Anticancer. (Nakoti *et al*., 2017)

Brahmamanduki/Mandukparni

General information, morphology and habitat

Brahamamanduki has been used as a medicine in the Ayurvedic tradition of India for thousands of years (Gohil, *et al.*, 2010). This plant is a prostate, faintly aromatic, perennial, creeper herb with height up to 15cm. Stem is glabrous, striated, rooting at the nodes. It flourishes extensively in shady, marshy, damp and wet places forming a dense green carpet. The leaves have crenate margins and are glabrous on both sides. Flowering in the plant occurs in the month of April-June. Seeds have pedulous embryo which are laterally compressed (Singh *et al*., 2010). *Centella asiatica* is indigenous to warmer regions of both the hemispheres including India, Sri Lanka, South- East Asia, parts of China, Western South Sea Islands, Mexico, South East USA, South Africa, Columbia, Eastern South America, Venezuela and Madagascar (Zahara *et al.*, 2014).

Vernacular identification

The plant is commonly known as Gotu Kola [Hindi], Brahmamanduki [Sanskrit], Asiatic pennywort/ Indian pennywort or Spade leaf [English].

Taxonomic classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Apiales

Family: Apiaceae

Genus: *Centella*

Species: *Asiatica*

Image 7: *Centella asiatica* plant

Phytochemistry and polyphenolic constituents

Polyphenols, flavonoids, tannins, terpenoids, vitamin C, β-carotene and p-coumaric acid are present as secondary metabolites in different parts of the plants. These secondary metabolites play an important role as antioxidants and have antimicrobial activities. Leaf extracts of plants have greater presence of flavonoid as compared to that of stem extract. However, the phenol content is higher in the stem extract as compared to that of the leaf extract. Ethanolic leaf extract contains tannin, saponin, and glycoside in good quantities (Polash *et al.*, 2017). Flavanoids, 3-glucosylquercetin, 3- glucosylkaemferol and 7-glucosylkaemferol have been isolated from the leaves (Singh *et al*., 2010). Recently, two new flavonoids named castilliferol 1 and castillicetin 2 (both exhibiting antioxidant activity), as well as a known compound, isochlorogenic acid 3, were isolated from the whole plant. The flavonoids apigenin, rutin and quercetin have been detected in methanolic extracts of *C. asiatica* (European Medicines Agency, 2012). The roots of *C. asiatica* are rich in amino acids, specially glutamic, serine, alanine, threonine, aspartic, histidine and lysine (Zahara *et al.*, 2014).

Pharmacological activities associated with polyphenolic contents of plant parts

Whole plant is used for the treatment of mental fatigue, diarrhea, urinary tract infections, hypertension, wound healing, rheumatism, indigestion, leprosy, poor memory, liver ailments and as brain tonic.

Leaves of *C. asiatica* exhibit highest antioxidant activity as leaves contain the highest phenolic content as compared to other parts of the plant. Also used for mental illness and leprosy treatment.

The alcoholic extract of the plant shows good antibacterial activity. Centella asiatica is also found to have antiulcer, antidiabetic, cardioprotective and immune-modulating effects (Zahara *et al.*, 2014).

Kutki

General information, morphology and habitat

The plant is known to have been used in medicine since 5000 years ago. The name of “Picros” means bitter in taste and “Rhiza” refers to root, thus the *Picrorhiza* signifies bitter boot and is used in ancient as well as modern periods extensively. Though it has multiple medicinal properties, it was mainly used for hepatoprotective quality since ancient times (Bhattacharjee, 2013).

Plant is perennial in nature with elongated roots. Leaves are about 5-10 cm, rounded tip, narrow at base and saw-toothed. Flowers are pale purple or white in colour. Rhizome is 5- 12 cm long, straight or slightly curved. The outer surface of the rhizome is scaly and grey or brown in colour. Roots are cylindrical and thin, mostly attached with rhizomes (Thani, 2021).

The plant generally grows at the altitude range of about 3000 to 5000 metres above sea level of Himalayan region, though it can be cultivated at lower altitudes also. Himachal Pradesh has its presence in districts such as Chamba, Shimla, Kinnaur, Kangra, Lahaul and Mandi. In the Kashmiri region of Himalayas it is found in Sindh, Lolab, Gurez and Keran valleys. It is also reported in Nepal, Bhutan, China and Pakistan (Maria *et al*., 2015).

Vernacular identification

Katuka/ Kutki [Hindi], Katuka [Sanskrit], Kattki [Bengali], Kaundd [Punjabi], Kali katuki [Marathi], Kadu [Gujarati], Katukarohini [Telugu], Katukarogini [Tamil]

Taxonomic classification

Kingdom Plantae

Division Dicotiledonae

Class Asteride

Order Scrophulariales

Family Scrophulariaceae

Genus: *Picrorhiza*

Species: *Picrorhiza kurroa*

Image 8: *Picrorhiza kurroa* plant

Phytochemistry and polyphenolic constituents

Chief chemical contents of the plant root and rhizome extracts are apocyanin, androsim, Kutkiol, androsim, D-mannitol, aromatic acids , ferulic acid , vanillic acid , cinnamic acid , Kutkisterol, iridoid glycosides (picroside I and II), Kutkoside, arvenin III, minecoside, picrorhizin (Maria *et al*., 2015). Chemical studies show that Kutkin is the active principle of the plant, which is made up of kutkoside and iridoid glycoside picrosides I, II, and III. Phytochemicals like pikuroside, phenol glycosides, cucurbitacin glycosides, veronicoside, 4- hydroxy-3-methoxy acetophenone have also been reported in

Picrorhiza kurroa (V. Prakash, 2020). Studies on many bioassays on the isolated contents of rhyzomes revealed that the bioactive components found are apocynin, cucurbitacin glycosides, drosin, acetophenones, catechol- apocynin (Diksha *et al*., 2021).

Pharmacological activities associated with polyphenolic contents of plant parts

Dried Root and Rhizome: Antiasthemic, hepatoprotective, immunomodulatory, anti- dysentery, anti- diarrhea, anticancer, anti-diabetic, anti-oxidant, anti-inflammatory, anti-microbial, antiallergic, anti-malarial, cardioprotective, neuritogenic, hypolipidemic, purgative, anti- scorpion poisoning, useful in peptic ulcer, skin disorders, rheumatic arthritis, neuralgia, upset stomach, vitiligo.

Brahmi

General information, morphology and habitat

Bacopa monnieri Linn. Known as 'Brahmi' in Hindi and water hyssop in English, it is a perennial, creeping herb with small leaves, white or purple flowers belonging to the family Schrophulariaceae (Rai *et al.*, 2017). Traditionally, it was used as a brain tonic to enhance learning & memory, and to provide relief in anxiety or epileptic disorders.

Bacopa monnieri, a member of the Scrophulariaceae family, is a small, creeping herb with numerous branches, small oblong leaves, and light purple flowers. In India and the tropics, it grows naturally in wet soil, shallow water, and marshes. Stem is thin, green or purplish green, about 1-2 mm thick, 10-30 cm long, soft; nodes and internodes are prominent, glabrous; and taste slightly bitter. Leaves are simple, opposite decussate, green, sessile, 0.6-2.5 cm long, 3-8 mm broad, obvate-oblong; and taste slightly bitter. Flowers are small, axillary and solitary, pedicels 6-30 mm long, bracteoles shorter than pedicels. Fruits are capsules upto 5 mm long, ovoid and glabrous. Root is thin, wiry, small, branched and creamish-yellow in color (Kumar *et al*., 2016).

In India and the tropics, it grows naturally in wet soil, shallow water, and marshes. It is also found in Nepal, Srilanka, China, Taiwan, Vietnam, Florida and Southern states of the USA. It is widely distributed in warmer parts of Asia, Australia, America and India (Yadav and Reddy, 2013).

Vernacular identification

Bacopa monneri, has many vernacular names as Brahmi [Common name], Brahmi sak [Bengali], Water Hyssop, Thyme leaved gratiola [English], Brahmi, Jalnim [Hindi], Nirubrahmi [Kannada], Brami [Malayalam], Nirbrahmi [Marathi], Aindri, Brahmi [Sanskrit], Nir pirami [Tamil], Sambrani Chettu [Telugu], Jalanim [Urdu].

Taxonomic classification

Kingdom: Plantae

Division: Tracheophyta

Class: Magnoliopsida

Order: Lamiales

Family: Schrophulariaceae

Genus: *Bacopa*

Species: *monnieri (L.)*

Image 9: *Bacopa monneri* plant

Phytochemistry and polyphenolic constituents

The phytochemical screening of extract of *Bacopa monnieri* pennel reveals the presence of many therapeutically important compounds such as glycosides, alkaloids, saponins, phenols, proteins and carbohydrates (Ashalatha and Shenoy, 2016). *Bacopa monniera* contain alkaloid brahmine , nicotinine, and herpestine. Triterpenoid saponins, saponins A, B and C and pseudojujubogenin glycoside were also isolated from Bacopa monniera. Bacopasides I, II, III, IV and V were also isolated from Bacopa monniera. Bacopa monniera also contained betulinic acid, D-mannitol, stigmastanol , β-sitosterol and stigmasterol (Ali Esmail Al-Snafi, 2013).

Pharmacological activities associated with polyphenolic contents of plant parts

Whole plant: Ethanolic extract of Bacopa monnieri is rich in saponins and it possesses hepatoprotective property which is attributed to bacoside-A (Rai *et al.*, 2017). It effectively suppresses inflammation by inhibiting the prostaglandins synthesis and partly by stabilizing lysosomal membranes. The anti-inflammatory activity of Bacopa monnieri is due to the triterpenoid and bacoside present in the plant.

Crude plant extract of Bacopa monnieri or bacosides have anxiolytic effects, antidepressant activity, anticonvulsant action and antioxidant activity. The active compounds in Bacopa monnieri (L.) Pennell, known as bacosides, positively influence brain cells that prompt the regeneration of brain tissue. Bacosides A and B, bacopasides I and II and bacopasaponin C and the extract of Bacopa monniera exhibit antidepressant activity (Ali Esmail Al-Snafi, 2013).

Oil: Oil prepared from the alcoholic extract of Brahmi shows hair growth promoting effect (Jain *et al*., 2016).

Gurmar

General information, morphology and habitat

Gymnema sylvestre is a well-known medicinal plant used for treating many disorders since traditional times. The nomenclature Gymnema comes from a Hindi language word ‘Gurmar’ which means ‘destroyer of sugar’ in India, due to its sugar reducing potent medicinal abilities. The plant has deep roots and significant mention in the Ayurveda system of medicine, considering it as a key botanical resource to treat diabetes and many other metabolic disorders. It has proven valuable medicinal properties due to the presence of numerous bioactive compounds (Tiwari *et al*., 2014).

Gymnema sylvestre is a slow-growing, woody and perennial climber of up to a height of 600 metres. It is heavily branched and runs all over the tall trees. The young leaves and stem are pubescent which means they are covered with short and soft hair. Leaves are ovate-elliptic, around 3- 5 cm long and 3 cm broad. Flowers are small and yellow in colour. Seeds are brown and thin, flat and ovoid in shape about 1-1.5 cm long. Generally, flowering occurs in October to January and it bears fruits from March to the month of May (Amiza *et al*, 2020).

The plant is a very common climbing botanical in the central and southern part of India. It has a scattered presence in monsoon forest, riverine forests and in dry, sandy & loamy soils. The existence has also been reported in almost all tropical zones of Sri Lanka, China, Japan, Africa, Indonesia, Malaysia, Thailand and Vietnam.

Vernacular identification

Gurmar [Hindi], Meshashringi/ Madhunashini [Sanskrit], Adigam [Tamil], Kalikardori [Marathi], Sannagerasehambu [Kannada], Dhuleti/ mardashingi [Gujrati], Podapatri [Telugu]

Taxonomic classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Gentianales

Family: Asclepiadaceae

Genus: *Gymnema*

Species: *sylvestre*

Image 10: *Gymnema sylvestre* plant

Phytochemistry and polyphenolic constituents of *Gymnema sylvestre*

Stems of the plant have been found to contain triterpenoid saponin and stigmasterol. It also has some amounts of Gymnemic acids (Khan *et al*., 2019).

The constituents of **leaves and plant part extracts** are flavones, flavonoids, d-Quercitol, lupeol, resins, anthraquinones, kaempferol, gymnemic acid, gymnema saponins, e epicatechin, β-amyrin, pentatriacontane. (Jamadagni *et al*., 2021). Besides, these are also reported to have antioxidants such as tannins, butyric acid, cinnamic acid, ascorbic acid, alkaloids, tartaric acid and phenols etc. (Laha and Paul, 2019). Studies show the presence of total phenolic content of leaves is about 19.8 mg/g and flavonoid is 2.65 mg/g (Bahera and Suraj, 2019).

Pharmacological activities associated with polyphenolic contents of plant parts

Leaves- Anti- obesity, anti- diabetic, hypolipidaemic, purgative, anti-inflammatory, anti-arthritic, anti-microbial, sedative, diuretic, antipyretic, expectorant, stomachic.

Whole plant- Hepatoprotective, anti-tumor, anticancer, antioxidant, antiarthritic, immunomodulating activity, anti-inflammatory, anticaries, useful in conjunctivitis, dysentery, vomiting and gastric upsets, amenorrhoea and leucoderma.

Conclusion

Quite a lot of scientific researchers has provided significant evidences to prove the efficacy and confirmed that polyphenols have attained a prominent position in protection against the development and progression of many chronic pathological conditions as cancer, diabetes, aging, cardiovascular diseases and many more health conditions known for their complexities and detrimental nature. Current scientific understanding has confirmed that polyphenols of medicinal plants can offer great hope in the medical and nutrition field.

Though there are many plants and trees well known among folkloric medical practitioners of rural and tribal areas for their medicinal properties, compromised in research and documentation. More extensive studies and experimentation on a large number of medicinal plants are required to incorporate and use these valuable compounds of polyphenols in various medicines and related products. The role of polyphenols in medicinal plants is still a very fertile area with great scope of research. A better understanding will facilitate and enable the health care system to treat and prevent a wide spectrum of diseases with better abilities that too with least possible adverse effects.

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